Original Scientific paper
10.7251/AGREN2601093B
UDC 636.5:619

PHYSIOLOGICAL AND BIOCHEMICAL ASSESSMENT OF JAPANESE QUAIL MEAT AND BLOOD PROFILES BY AGE AND SEX

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ABSTRACT

Quail farming is gaining global importance due to the species' rapid growth, early maturity, high productivity, and disease resistance. Quail meat is valued for its nutritional and medical properties, competing favorably with broiler and turkey meat. This study aimed to evaluate age- and sex-related differences in the chemical composition of Japanese quail (*Coturnix japonica*) meat and blood parameters to determine optimal slaughter timing. A total of 72 Japanese quails (*Coturnix japonica*) (aged 5-8 weeks, both sexes), raised under identical conditions, were studied. Hematological and biochemical blood parameters, as well as meat chemical composition, were analyzed. Results showed that male quails had significantly higher hematocrit (HCT), red blood cell count (RBC), haemoglobin (Hgb) and high-density lipoprotein (HDL) cholesterol, but lower total protein (TP), triglycerides (TGL), calcium (Ca), and alanine aminotransferase (ALT) compared to females ($p<0.05$ for most parameters). With increasing age, HCT, RBC, and Hgb increased in both sexes, while aspartate aminotransferase (AST) activity declined. In females, blood Ca levels raise significantly with age. Regarding meat composition, male quails exhibited 28.5% higher salt content ($p>0.05$) than females, with no significant sex-based differences in moisture, fat, or protein levels. Meat moisture decreased ($p<0.05$) and fat content tended to increase with age. These findings demonstrate that both age and sex significantly influence blood parameters and meat composition (in a lesser extent) in quails. Such data may inform breeding and slaughter strategies to maximize meat quality and animal health.

Keywords*: quails, haematological parameters, biochemical parameters, chemical composition of meat.*

INTRODUCTION

The Japanese quail (*Coturnix japonica*) is the most widespread subspecies of migratory Old World quail, originally native to East Asia. It was domesticated in Japan as early as the 12th century, and between 1930 and 1950, it began to be bred

in the United States, the Middle East, and Europe (Goodson J. *et al*., 2015; Taha A.E. *et al*., 2019). Initially kept as songbirds, by the early 20th century, Japanese quails gained popularity due to the high nutritional value of their meat and eggs. Since the 1960s, they have also been widely used in scientific research (Yasin B. *et al*., 2020). In poultry farming, Japanese quails (*Coturnix japonica*) are appreciated for their rapid growth rate, early sexual maturity, high egg-laying capacity, low maintenance requirements, and strong resistance to diseases (Hajkhodadadi I. *et al*., 2013). Due to their favorable nutritional profile and certain health benefits, quail meat is considered a delicacy and competes successfully on the global market with broiler chicken and turkey meat (Goodson J. *et al*., 2015). The nutritional quality of the meat is closely linked to its chemical composition, which is influenced by several factors, including genotype, feeding regimen, age at slaughter, and sex of the birds (Genchev A. *et al*., 2008). Accordingly, the aim of this study was to determine the effects of age and sex on the chemical composition of Japanese quail (*Coturnix japonica*) meat in order to establish the optimal slaughter time for each sex.

One of the key factors in successful quail farming is maintaining flock health, which depends not only on proper disease prevention and control, but also on early diagnosis (Islam Md. *et al*., 2016). One of the most commonly used laboratory diagnostic methods in veterinary clinical practice is the analysis of hematological and biochemical blood parameters. These indicators can be significantly influenced by factors such as breed, sex, age, diet, and subclinical infections (Onyinyechukwu A. *et al*., 2017). Therefore, the second objective of this study was to evaluate age- and sex-related changes in the biochemical and morphological parameters of quail blood.

MATERIAL AND METHODS

Rearing Conditions. Japanese quails were raised under age-appropriate environmental conditions. Hatching was performed using an on-site incubator. Chicks (0 – 21/25 days) were kept in brooders lined with peat, heated with electric lamps (34-37 °C, 65% humidity), and fed a balanced starter feed with water supplied via nipple drinkers. Stocking density: 150 cm² per bird. At 21 – 25 days, chicks were moved to heated rearing facilities (18 °C, 65% humidity), housed on wire flooring, fed nutritionally adequate feed from troughs, and watered via nipple systems. Stocking density: 170 cm² per bird. Lighting was controlled at 18 h/day. Feed consisted of wheat, barley, rapeseed meal, flaxseed, corn, fishmeal, soybean meal, and peas.

Experimental Group Formation. To assess age and sex effects on blood and meat parameters, quail chicks hatched on May 24 and June 7 were divided into four experimental groups after sexing. Birds from May 24 were raised to 7 and 8 weeks of age; those from June 7 – to 5 and 6 weeks. Each group included 9 females and 9 males. In total, 72 clinically healthy birds were used and reared under identical conditions from 2.5 weeks of age until slaughter.

Experimental Procedure. Two groups of clinically healthy quails – 5-week-old and 7-week-old – were slaughtered on July 12 with a 4-hour interval between groups.

Decapitation was performed using specialized scissors. The remaining two groups – 6-week-old and 8-week-old birds – were slaughtered in the same manner on July 19. Prior to slaughter, all birds were fasted for 30 minutes.

Blood Sample Collection and Analysis. Immediately following decapitation, blood samples were collected by severing the jugular vein. For hematological analysis, 1 mL of blood from each bird was placed into pre-labeled sterile tubes containing ethylenediaminetetraacetic acid (EDTA). Within one hour of collection, samples were analyzed using the IDEXX ProCyte Dx® hematology analyzer to determine the following parameters: red blood cell count (RBC), hematocrit (HCT), hemoglobin concentration (Hgb), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). For biochemical analysis, 2 mL of blood was collected from each bird into pre-labeled sterile tubes containing lithium heparin. Samples were centrifuged (2000 rpm, 10 min, within 30 min of collection). The resulting plasma was transferred into labeled Eppendorf-type microtubes and stored at -20 °C until analysis. On the day of testing, the samples were thawed for 2 hours and mixed using a tube mixer to ensure homogeneity. Plasma biochemical parameters – including aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), total protein (TP), triglycerides (TGL), high-density lipoprotein (HDL), calcium (Ca), and phosphorus (P) – were analyzed using the "Dialab Autolyser" clinical biochemistry analyzer (DIALAB®, Austria).

Meat Sample Collection and Analysis. After exsanguination, breast and thigh muscles were collected. Three individual samples per sex were combined into 200 g pooled samples (six per group). Samples were stored at 1 °C for 12 hours and analyzed using a FoodScan™ (NIR) analyzer for fat, protein, moisture, collagen, collagen-free protein, connective tissue, and salt.

Statistical Analysis. Data were processed using IBM SPSS Statistics 20.0 and Microsoft Office Excel. Mean values and standard deviations were calculated. Two-way ANOVA model was used to test three hypotheses: the effect of factor A (age), the effect of factor B (sex), and the interaction effect between the two factors (A×B). Student's t-test was used to assess the statistical significance of differences between means. Differences were considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

This study evaluated the influence of physiological factors – age and sex – on the hematological (Table 1) and biochemical (Table 2) blood parameters, as well as the chemical composition of meat (Figure 1. and Figure 2.) in Japanese quail.

Table 1. Age- and sex-related hematological parameters of Japanese quail.

	RBC, 10^{12}/L	HCT, %	Hgb, g/dL	MCV, fL	MCHC, g/dL
Group	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)
F	3.363 (0.094)	37.692 (1.238)	14.233 (0.438)	112.108 (2.821)	37.950 (1.168)
M	3.590 (0.094)	42.508 (1.238)	14.783 (0.438)	117.675 (2.821)	35.317 (1.168)
5-weeks	3.095 (0.132)	37.550 (1.751)	13.717 (0.619)	121.517 (3.990)	36.683 (1.652)
6-weeks	3.007 (0.132)	34.733 (1.751)	12.617 (0.619)	112.850 (3.990)	36.867 (1.652)
7-weeks	3.722 (0.132)	43.433 (1.751)	16.500 (0.619)	116.100 (3.990)	38.400 (1.652)
8-weeks	4.083 (0.132)	44.683 (1.751)	15.200 (0.619)	109.100 (3.990)	34.583 (1.652)
Norm	2.02–6.99	25.00–66.00	8.61–20.57	64.68–131.91	20.77–64.28

In the present study, male Japanese quail exhibited higher mean values of hematocrit (HCT) ($p<0.05$), red blood cell count (RBC), hemoglobin (Hgb), and mean corpuscular volume (MCV) ($p>0.05$), whereas females showed elevated mean values of mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) ($p>0.05$). These sex-related hematological patterns are consistent with the findings of Abou-Kassem D. E. *et al*. (2019), who also reported significantly higher RBC, HCT, and Hgb values in males. Similar trends – elevated MCH and MCHC in females and HCT in males – were observed by Onyinyechukwu A. *et al*. (2017), while Hajkhodadadi I. *et al.* (2013) confirmed sex-based differences in HCT values. Comparable variations have also been reported in other Galliformes species: Addass P. A. *et al*. (2012) found higher HCT, RBC, and MCV values in male chickens. These differences are thought to reflect the stimulatory effect of steroidal androgens on erythropoiesis (Peters S. O. *et al.*, 2011).

Regarding biochemical parameters, females demonstrated significantly higher mean concentrations of total protein (TP), triglycerides (TGL), calcium (Ca), and phosphorus (P) ($p<0.05$), as well as non-significantly elevated alkaline phosphatase (ALP) activity ($p>0.05$). In contrast, males exhibited significantly higher levels of alanine aminotransferase (ALT) ($p<0.05$), high-density lipoprotein (HDL) cholesterol ($p<0.001$), and non-significantly higher aspartate aminotransferase (AST) ($p>0.05$). Similar sex-based differences in TP, TGL, Ca, and P concentrations were described by Abou-Kassem D. E. *et al*. (2019) and Onyinyechukwu A. *et al*. (2017). The elevated levels in females are closely linked to reproductive physiology

– particularly the onset of egg laying – when hepatic biosynthesis of lipids and yolk precursors intensifies (Onyinyechukwu A. *et al*., 2017; Li H. *et al*., 2017).

Table 2. Age- and sex-related biochemical parameters of Japanese quail.

	AST, IU/L	ALT, IU/L	ALP, IU/L	TP, g/dL	TGL, mg/dL	HDL, mg/dL	Ca, mg/dL	P, mg/dL
Group	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)
F	128.750 (9.366)	48.767 (2.236)	312.092 (78.458)	4.102 (0.177)	746.500 (81.086)	31.454 (5.959)	10.099 (0.547)	37.692 (1.238)
M	144.167 (9.366)	33.142 (2.236)	160.692 (78.458)	2.590 (0.177)	121.750 (81.086)	101.692 (5.959)	3.864 (0.547)	42,508 (1.238)
5-weeks	176.000 (13.246)	36.900 (3.162)	116.500 (110.957)	2.793 (0.251)	440.500 (114.673	69.968 (8.428)	5.320 (0.774)	5.348 (1.053)
6-weeks	169.833 (13.246)	45.567 (3.162)	191.367 (110.957)	3.250 (0.251)	495.000 (114.673	73.883 (8.428)	7.162 (0.774)	6.452 (1.053)
7-weeks	121.167 (13.246)	46.433 (3.162)	284.217 (110.957)	3.427 (0.251)	421.000 (114.673	59.940 (8.428)	7.428 (0.774)	5.262 (1.053)
8-weeks	78.833 (13.246)	34.917 (3.162)	353.483 (110.957)	3.913 (0.251)	380.000 (114.673	62.500 (8.428)	8.017 (0.774)	6.985 (1.053)
Norm	23.85–90.7	10.17–38.5	86.21–113.2 9	2.75–7.84	153.00–273 00	110.00	5.23–10.63	5.16–6.28

According to Hassan H. M. *et al.* (2007), increased TGL levels are typically associated with higher low-density lipoprotein (LDL) cholesterol and reduced HDL cholesterol concentrations, which aligns with the present observation of significantly reduced HDL in females with elevated TGL. Estrogen-induced upregulation of vitellogenin and other yolk precursors contributes to higher plasma protein levels during the laying cycle (Li H. *et al*., 2017). Furthermore, elevated Ca and P levels in female quail are supported by the action of hormonal regulatory mechanisms, such as enhanced intestinal absorption and bone mobilization (Igwe A. O. *et al*., 2018). Increased ALP activity in females may reflect its role in eggshell mineralization and its association with laying cycles (Bud C. *et al*., 2008). Although higher ALT activity was observed in males, limited reference in the literature prevents conclusive interpretation of this finding.

Age was found to be a significant determinant of hematological and biochemical variations in Japanese quail. The observed progressive increase in RBC, Hgb, and HCT values between 6 and 8 weeks of age likely reflects enhanced hematopoietic activity associated with physiological maturation. These findings support the hypothesis that age-related endocrine changes – particularly the increased secretion of gonadotropins and metabolic intensification – stimulate erythropoiesis (Puspamitra S. *et al*., 2014). Discrepancies in MCV values ($p<0.05$) may be attributed to interindividual variability across separate age groups rather than temporal changes within the same individuals.

On the biochemical level, the current results confirm a trend of age-associated increases in key plasma components – TP ($p<0.05$) and Ca ($p>0.05$) – as previously documented by Onyinyechukwu A. *et al*. (2017), Abou-Kassem D. E. *et al*. (2019), and Hassan H. A. (2010). The sharp rise in TP concentration in 6-week-old females likely signals the onset of vitellogenesis, with hepatic biosynthesis of yolk precursors intensifying under estrogenic stimulation (Tabinda K. *et al*., 2013). Similarly, elevated calcium levels in older birds may reflect increased physiological demand for mineral deposition in developing oocytes (Abou-Kassem D. E. et al., 2019). Although not statistically significant, the spike in ALP activity in 6-week-old females further supports this interpretation, suggesting enzymatic involvement in the initiation of eggshell calcification. The age-related decline in AST activity, while statistically non-significant ($p>0.05$), aligns with patterns of hepatic enzyme modulation during sexual maturation. However, as shown by Keçeci T. et al. (2011), such trends are not consistently observed across all Galliformes, highlighting potential species-specific regulatory mechanisms.

The chemical composition of meat from quail of different sex and age groups is presented in Figures 1 and 2.

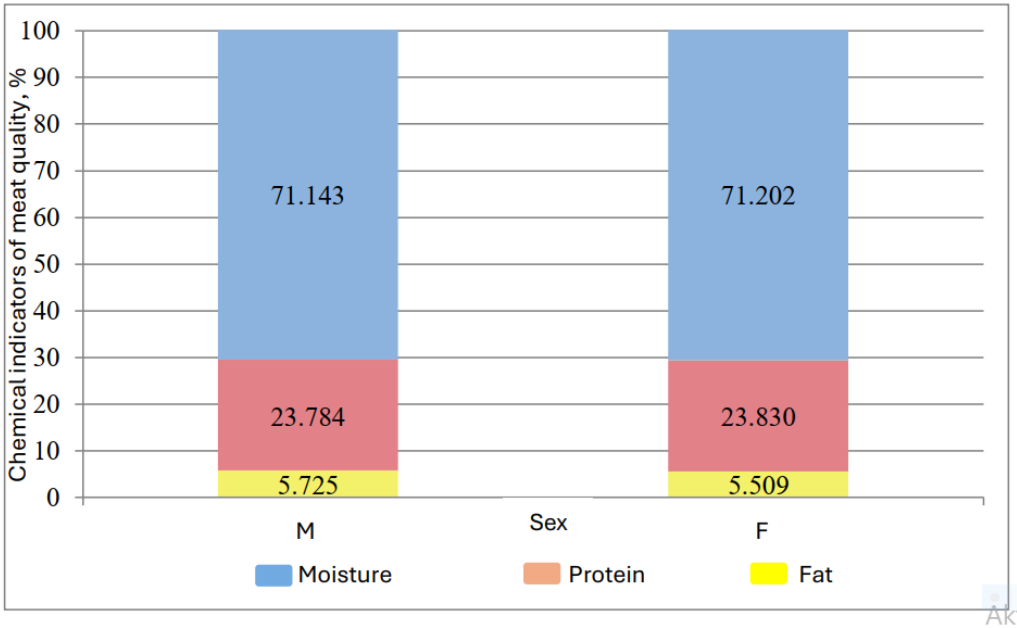

Fig. 1. Sex-related differences in quail meat composition

Differences in meat composition between male and female quail were minor and statistically insignificant. Similar findings were reported by Sartowska, K. E. *et al.,* 2014 and Genchev, A. *et al.,* 2008, who found no significant differences in moisture, protein, fat, carbohydrate, or ash content between male and female quail meat. In contrast, Abou-Kassem D. E. *et al*., 2019 and Magubane, M. M. *et al.,* 2013 observed

a significantly higher fat percentage in the meat of females, while other compositional parameters were not affected by sex.

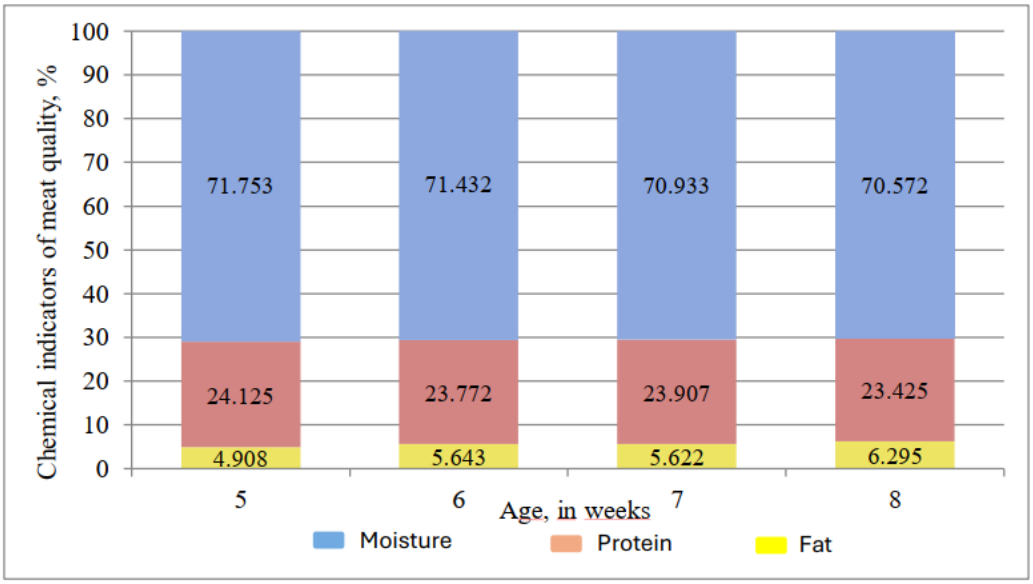

Fig. 2. Age-related differences in quail meat composition

When evaluating age-related changes in the chemical composition of quail meat, a significant decrease in moisture content with increasing age was observed ($p<0.05$), while the changes in other meat components were inconsistent. Similar trends in moisture reduction have been reported by Abou-Kassem D. E. *et al*., 2019 and Boni I. *et al*., 2010. The decrease in moisture content is generally associated with a relative increase in the proportion of other compositional components.

The study revealed a significantly higher fat content ($p<0.05$) and lower protein content ($p<0.01$) in the meat of 8-week-old quail compared to that of 5-week-old birds. An age-related increase in fat content and decrease in protein proportion in quail meat was also reported by Boni I. *et al*., 2010. In contrast, Abou-Kassem D. E. *et al*., 2019, observed a significant increase in meat protein content with advancing age.

CONCLUSIONS

Regardless of age, clinically healthy male quail exhibited higher values of hematological and biochemical blood parameters compared to females ($p<0.001$). However, female quail had higher levels of MCH (by 2.1%, $p>0.05$), MCHC (7.5%, $p>0.05$), ALT (47.1%, $p<0.001$), TP (58.4%, $p<0.001$), TGL (513.0%, $p<0.001$), Ca (161%, $p<0.001$), P (49%,$p<0.05$), and ALP (94.2%, $p>0.05$) compared to males. Age-related analysis showed that HCT ($p<0.05$), RBC, and Hgb ($p>0.05$) increased with age in both sex, while AST levels decreased ($p>0.05$). In females, blood Ca ($p<0.05$) and TP ($p>0.05$) concentrations also increased progressively with age. Moisture content decreased significantly with age ($p<0.05$), while fat content

showed a non-significant increase ($p>0.05$). From a dietary perspective, meat from 5-6-week-old quail is considered most valuable due to its lower fat content and higher protein levels.

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